

**PROCEEDINGS  
TWELFTH WORKSHOP  
GEOHERMAL RESERVOIR ENGINEERING**

**January 20-22, 1987**



**Henry J. Ramey, Jr., Paul Kruger, Frank G. Miller,  
Roland N. Horne, William E. Brigham,  
Jesus Rivera  
Stanford Geothermal Program  
Workshop Report SGP-TR-109\***

## **DISCLAIMER**

**This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.**

## **DISCLAIMER**

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**

GEOTHERMAL ENERGY - AN EMERGING RESOURCE

Dr. John R. Berg

U.S. Department of Energy

It is a pleasure to address the geothermal reservoir engineering community tonight. Although I will not be able to attend all of the technical sessions, I am pleased to discuss the issues with which I am most familiar -- the Department of Energy's overall energy policy, the role of alternative energy resources within the policy framework, and, specifically, our expectations for geothermal energy.

While our expectations are high for geothermal energy, based upon current geothermal industry performance, they are realistic. Your industry is to be congratulated on its farsighted decision to open a number of reservoirs to development with small "ice-breaker" plants during this period of grace in the long-term outlook for energy supply and cost. In recognition that the current over-supply of oil and electric power in geothermal areas and bargain oil prices are very likely to be transitory, your industry is preparing itself to be ready to serve an expanded energy market at prices that should reward your current wisdom.

The Department is delighted that you have embarked on this course. It is our contention that, sooner or later, OPEC to some extent will succeed in determining the prices and quantities of petroleum supplies. Since our economic prosperity and national security depend on a constant flow of reasonably priced energy from reliable suppliers, and that oil is a finite resource, our concern is that undue complacency in any quarter of the energy market is a challenge to our future.

Estimates from the Department of Energy, the Energy Information Administration, the National Petroleum Council, and the American Petroleum Institute all show that rising consumption and lower domestic energy production could push U.S. oil imports up sharply by the mid-1990's. Other nations are experiencing similar trends, and it is entirely possible that the Persian Gulf will once again be supplying half of the world's oil in the next 10 years.

That is virtually the same situation the world faced in the 1970's -- a time when market manipulations by a single set of energy suppliers nearly tripled the price of oil. The future formula could be a similar one:

increased consumption and decreased domestic production added to increased imports ultimately adding up to out-of-control price spirals and renewed dependence on insecure and volatile foreign sources of oil. We cannot afford to let this happen again. Energy is too vital a component of our national security to allow a new cycle of overdependence on foreign sources, supply shortages, and rapid price increases.

This administration is dedicated to that goal. Our ideal is an economically efficient, flexible energy system which avoids undue dependence on any single source of supply. This means the development of an adequate technology base for all sources of energy, from conventional sources such as our domestic fossil fuels, to nuclear, to every form of renewable energy which, through research, continued technological advances, and market expansion, stands an excellent chance of being cost-competitive in the future. With every small improvement in the new technologies, with every new facility that opens, the prospect of our developing and conserving domestic sources of energy and avoiding undue dependence on any one source is enhanced.

The Department of Energy projections suggest that supplies from alternative technologies will continue to increase throughout the rest of this century and may represent more than 13 percent of domestic energy supply by the year 2010. In fact, on a percentage basis, geothermal energy is currently the fastest growing source of new energy supplies. Clearly, we need to continue public and private efforts to make alternative technologies more efficient, more reliable, less expensive, and readily available. We need to work for the day when these technologies are no longer "alternative," but a normal part of daily life.

The Department of Energy is committed to supporting technological innovation. Our own research program concentrates on high potential projects that are too risky and expensive for private industry to pursue alone. We are emphasizing basic and fundamental research which will expand the frontiers of our scientific and technological knowledge. For it is through research that we will make the technological break-throughs which will enable

alternate sources of energy to be cost-competitive and provide the building blocks for innovation in all available energy resources.

I would like to emphasize that the involvement of private industry is fundamental to federal research, and we are inviting industry to participate in our research program through cost-shared projects. We also encourage geothermal industry representatives, both potential users and producers, to participate in our program planning activities and to let us know what is relevant, needed, and important.

We see cost-sharing as a means of multiplying government and private capital, as the best means of initiating technical transfer, and as a means of ensuring that work being done is both meaningful and effective. We, DOE, cannot take the product of the research to the marketplace where the public will benefit from the investment, but the private sector, sharing in the program, can. The geothermal community has an excellent record in this regard, both in participation in cooperative R&D projects and in its willingness to consult with and advise the Department on optimum R&D planning. The Department's Geothermal Technology Division recently compiled a list of over 30 cooperative ventures with industry and the public sector. These range from use of industry facilities for testing DOE-developed materials and technology to the large Heber Binary Plant Project in which industry and public agencies invested over \$60 million. Government/industry cooperation also extends well beyond these structured arrangements to include more informal cooperation in the field.

In addition to cooperating in the development and testing of technology, the U.S. geothermal community -- industry and the laboratories and universities that implement large portions of the R&D program -- is also generous with its time and expertise in consulting with the Department. This workshop is only one example of the opportunities made available each year for interchange among all parties concerned. The Electric Power Research Institute and Geothermal Resources Council annual meetings also afford opportunities to meet both formally and informally to discuss technology needs and priorities. Industry also makes itself available for service on several invaluable technology review panels on which I am sure many of you serve. These include the Lawrence Berkeley Laboratory review panel on geothermal reservoir engineering and the Sandia review panel on wellbore technology.

In addition, industry and the research institutions, including the U.S. Geological Survey, join in the annual program review of the Geothermal Technology Division to offer advice and counsel. Their participation was formalized during last October's review at Los Alamos where attendees were assigned to panels to evaluate priorities in hydrothermal R&D and in

development of technology for utilization of the advanced geothermal resources. These groups contributed two days of their time to this productive effort. In addition, industry suggested the possibility of contributing \$3.5 million per year for five years for cost-sharing with the Department in the development and testing of hydrothermal reservoir technology and drilling research.

As most of you know, this contribution can be made in several ways. One of these is the cost-shared development of DOE-funded technology, such as the borehole televiwer, through the Geothermal Drilling Organization. This arrangement expedites the availability of technology that does not attract equipment supplier interest due to the very limited market involved. DOE and industry are 50-50 partners in supporting this effort. A Geothermal Technology Organization is now being formed to apply a similar approach to reservoir technology and geothermal energy conversion systems.

Another cooperative mechanism involves joint field projects for which industry absorbs the cost of the logistical and operational aspects and DOE provides the scientific input and technology transfer. A project of this type might involve, for example, industry furnishing drilling cores, cuttings, and geophysical well logs for analysis and reservoir modeling under DOE funding. We believe that a combination of these approaches will result in the greatest contribution to the progress of geothermal technology.

In that connection, the Department has sought the counsel of the National Academy of Sciences in evaluating the whole range of mechanisms available for DOE/industry cooperative R&D ventures. The Academy study is currently underway, and it will report its recommendations to us in the near future.

Thus far, I have only addressed the Department's participation in developing a technology base for geothermal power generation. I would like to add that we have also used the authority given to us by Congress under the Geothermal Loan Guaranty Program to assist developers of new geothermal projects which met the requirements of the Loan Guaranty Act, such as the funding of construction of the Northern California Power Agency's first plant at The Geysers. NCPA was able to repay this loan 24 years early and to move on to construction of its second plant. Another very promising 30 MWe project by ORMESA is currently underway at East Mesa which was also made possible by a loan guaranty. In addition, similar support permitted early development of commercial establishments for using geothermal energy. These include the Geothermal Food Processors' onion drying plant in Nevada and the Oregon Trail Mushroom's establishment at Vale, Oregon. Both of these highly successful operations serve as models for other commercial geothermal enterprises to come.

All of the efforts of the geothermal community that I have enumerated here contribute substantially to the realization of the Department's goal of achieving a mixed and balanced resource base for this country. If we can achieve this goal, we may never again have to face the economic and energy chaos we experienced a decade ago.

What do we expect of geothermal energy in the future? The fifth National Energy Policy Plan, or NEPP V, published in 1985, projects that the annual geothermal input to the electricity grid will double between 1984 and 1990 and double again by the year 2000 to 0.68 quads, representing about 8300 MWe on line. The sixth NEPP is currently in preparation, and while I cannot second guess the statistics it will contain, I believe that the industry performance noted earlier will support an increase in these numbers.

Since the data were gathered for NEPP V, power plant development has occurred or is planned for a number of liquid-dominated reservoirs that are estimated by the U.S. Geological Survey to have the capacity to produce several thousand megawatts for a lifetime of 30 years. The performance and behavior of these fields are being tested and evaluated now with small facilities. If an energy shortfall occurs in the 1990's, as has been predicted by some

experts, your industry will be ready to meet the challenge with larger capacities. Most of the effort to characterize these reservoirs will be behind you, and you can gear up quickly as demand requires.

Your ability to cope expeditiously with an energy shortage is enhanced by the short lead times for construction of geothermal power plants once the capability of the reservoir is known. I don't need to remind this audience of the brief construction schedules for the first round of hot water plants or of plants at The Geysers brought on-line ahead of schedule. The Department commends your decision to pursue the longer-term field effort now when there is low demand for your product. You have recognized that you cannot take 10 to 15 years to find new energy sources, develop them, and bring the energy to market overnight. It just cannot be done, and you are building your future competitive position at this moment.

All of you here this evening are contributing in one way or another to the preparations for a substantial geothermal contribution to our energy security. We are grateful to you for the wisdom, foresight, and leadership that you are demonstrating in this effort.

Keep up the good work.